Electricity Generation from Speed Breaker by Air Compression Method using Wells Turbine

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(Received: 22-Jan-2020; accepted: 15-May-2020; published: 30-Jun-2020)
DOI: http://dx.doi.org/10.25073/jaec.202042.277

Abstract. *The whole world is now running after green energy. The utilization of energy is an indication for the growth of a nation. Maximum consumed energy come from conventional energy sources like gas, oil, coal etc. which are limited. It is difficult to meet up the demand with existing conventional energy resource. So, green energy or alternate energy can be the best way to meet increased demand today. Electricity can be produced from the speed breaker which is considered an alternate energy source of power generation. In our country, speed breaker is about 10 cm in height. Thousands of vehicles run over the road everyday which provide huge pressure on the road. A system could be developed to have about 10 cm deflection with huge downward pressure energy which would be used to rotate wells turbine by using compressed air. Enormous study had been carried out to improve power generation from speed breaker by using rack & pinion method and compressed air. But none of the study is carried out by using wells turbine from compressed air. In our research, a small model has been constructed. From the experimental data, it is seen that an average 500 N Load can give an output of 1V voltage / 0.7A current / 1.71 kWh power.*

Keywords

Alternate energy, Air compression, Wells turbine, Electricity generation from speed breaker.

1. Introduction

Electricity is a basic part of nature and it is one of the most widely used forms of energy across the globe [16]. Per capita energy consumption in USA is 9000 kWh (Kilo Watt hour) and in India, it is 1200 kWh [1]. Per capita energy consumption in Bangladesh at 2017 was 433 kWh. According to the Power Sector Master Plan, Bangladesh produces only 450 MW from the installed renewable energy capacity of 15,500 MW [2]. At present, 59% of total electricity generation in Bangladesh is being received from government power plant and 41% of net generation of the country is being received from rental and Independent power plant [3]. Bangladesh imports 3.5-4.0 million tons of petroleum and petroleum products per year that spent about $5 million in 2011 which is 10% more expense compare to year 2000. A developing country like Bangladesh can't afford this strong dependence on foreign oil in the near future without thinking any alternative way [18]. It is a need of time to think about non-conventional energy resources or renewable energy resources which are eco-friendly to the environment [13]. The use of conventional technology results in pollution which affects environment. Power extraction from speed breaker can be a great source of clean or green energy. Millions of vehicles today cross busy roads over the speed breakers having millions of weight every day. For this purpose, attempts are made to construct a reliable, reachable and portable model which can extract power using the weight of vehicle exerted on the road.

South African people has implemented alternative power source for lighting up small villages due to electricity crisis [4]. Electricity demand in Bangladesh includes agriculture, commercial service, industry, and domestic service sectors [5]. Recent survey on the energy consumption in Bangladesh had published a pathetic report that 14,647 villages do not still have electricity [6]. With the existing conventional energy resource the demand cannot be met up. In that case, the source of green energy can be the best alternative way. Kanak Gogoi in Guwahati has developed a contraption to generate power while a vehicle passing over a speed-breaker [7]. Currently Renewable energy sector meets 13.5% of the global energy demand and growth rate is very high in terms of other sources of conventional energy. Under these scenarios, renewables could reach up to 50% of the total share of mid-21st century with appropriate policies and new technology developments [8]. Mr. Amol Sheshrao Fawade conducted this study by using both air compression and rack & pinion method where he got 7.53 kWh power from 400 kg car [9]. Kiran Kolhe and Amar Pandhare got 35.31 kWh power per day for 1500 kg load by rack and pinion system [10]. At India, Dave Jaymin J. got inconsistent power from speed breaker by air compression method and average value of power was mentioned in his study [11]. Aswathaman.V and Priyadharshini.m made practical test by using different load and speeds [19]. Conventional energy source is the main source of power generation in our country. But we will not be able to have this gift forever. This leads us to the search for alternate power source. We are motivated for establishing a model that will work in desired way.

The aim of this paper is to produce electricity from a speed breaker when vehicle (load) passes over the road. For this purpose, a model is constructed that will use for power generation. The structure consists of semi curved dome steel, upper & lower table, springs, compression chamber, wells turbine etc. we convert the potential energy to rotational energy through a process. Kinetic and potential energies are generated from the vertical displacement when vehicles pass over the speed breakers [17]. When load is kept on semi curved dome above upper table, it can have ups and downs with respect to lower table. The load exerts a pressure on compression chamber which assists to compress the air. This compressed air impinges on the special type's wells turbine (similar to NACA 0015 profile) shaft coupled with generator. Rotations of turbine blades produce an excessive torque on generator shaft which cut the magnetic field of generator and produce electricity which is measured by multimeter. RPM is measured by tachometer.

2. Materials and methods

2.1. Materials

Speed breaker of vibrating type has been taken for this study. When vehicles will cross the speed breaker (Fig. 1), it will be compressed and af-

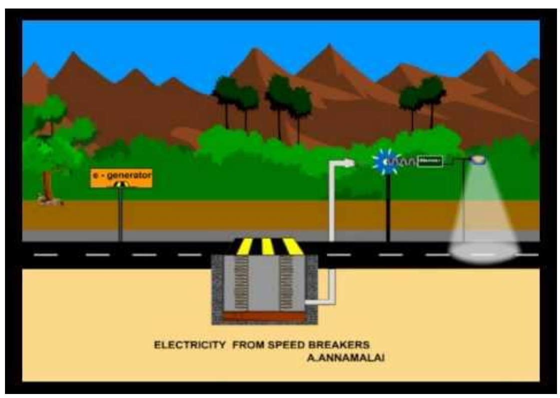

Fig. 1: Cross section of a speed breaker.

ter passing car, it will come back to its original position again. The following data has been considered.

a. Dimension:
   1) Height: 10 cm.
   2) Width: 40 cm.
   3) Length: 4 m.
b. Material: curved drum of steel.

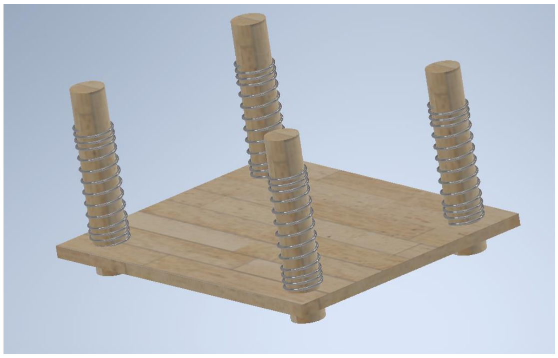

Fig. 3: Lower table.

2.2. Setup components

1) Upper and lower table

It consists of plywood and the thickness is 1/2 inch. This rectangular table dimension is 23" by 18". In lower table center hole diameter is 105 mm. Lower table (Fig. 3) is supported by 4 wooden bars which are placed at four corners of bottom of table. Four cylindrical pipes are also placed on the lower table at every corner of rectangular table. Upper table (Fig. 2) is used to hold the load of vehicles and lower table is used to hold the whole structure. Tables should have enough strength to withstand the load. So, we use plywood for this purpose because the grain of plywood is uniform, compact, and linear.

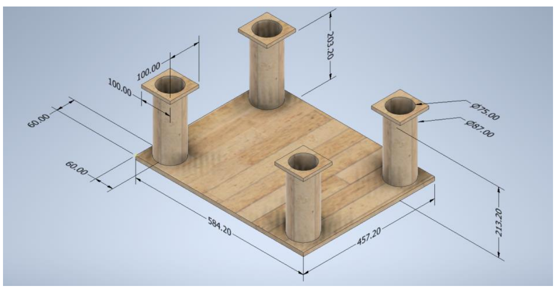

Fig. 2: Upper table.

2) Supporting tube

Four pipes are attached of two different diameters with upper and lower table which is made of plastic. Four pipes attached below the upper table is called upper pipe and similarly four pipes attached on the lower table is called lower pipe. The dimension of upper pipe length and diameter are 8 in and 87 mm and lower pipe length and diameter are 10 in and 56 mm. When load is given on upper table, the upper pipe can slide over the lower pipe. Lower pipe is inserted into 10 in diameter spring. Lower pipe strength is less considerable because it is used to slide the upper pipe and hold the spring. But upper pipe strength is most important because it transfers the load to compression chamber. So, thick upper pipe and thin lower pipe have been considered.

3) Spring

The researchers of this study have used 4 pieces of oil tempered, hardened, creep resistive, square grounded spring which have 6.5 number of active coils. Inner diameter is 60 mm and height are 193 mm and coil diameter is 5 mm which can easily mesh with lower pipe. Spring is used to return the structure (Fig. 4).

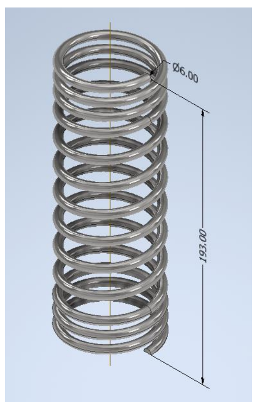

Fig. 4: Spring.

4) Shallow machine liner or compression chamber

Shallow machine liner (Fig. 5 & 6) is an assembly of piston and cylinder. It is made of cast iron. The liner is 216 mm in height and 120 mm in diameter. A connecting rod is connected to the piston and the piston can move up and down in the cylinder while force is exerted on the connecting rod. Thus air will be compressed. Piston and cylinder assembly was totally air tight.

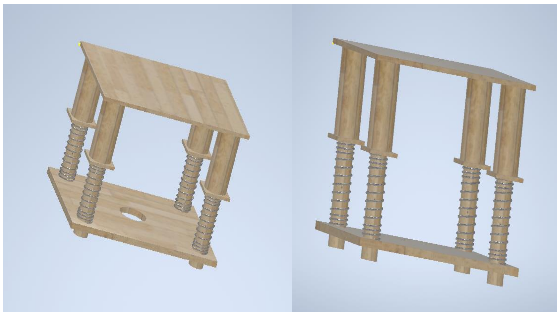

Fig. 5: Spring Setup with Upper Table and Lower Table.

Fig. 6: Shallow machine liner with four supporting tubes.

5) Wells turbine

Wells turbine is a unidirectional turbine where fluid flow can be in both directions. wells turbine (Fig. 7 & 8) has been chosen which is similar to NACA 0015 airfoil because for both directional flow of fluid this turbine will rotate only in same direction. Our designed wells turbine was 100 mm in diameter with five uniform wooden blades. Wooden blades had used because of its' light weight, and availability than any other material. For our research, five blades were chosen for getting optimum torque and suitable rotation. The inner circular shaped body is 60 mm in diameter and 1.5 mm thickness which holds all five blades. This wells turbine will be mounted with the generator shaft. Rotation of wells turbine will rotate the generator shaft. In generator, magnetic flux will be cut and thus, power will be produced.

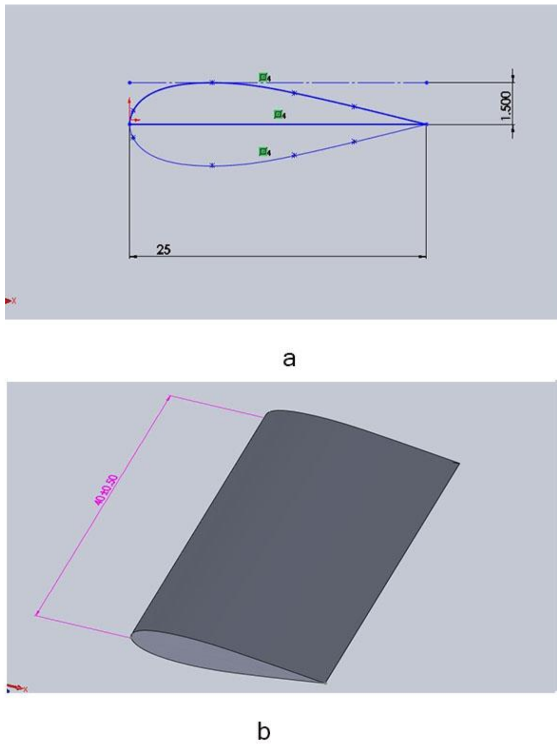

Fig. 7: Wooden Wells turbine (a) symmetric profile (b) one single blade.

6) Generator

Bi-cycle's dynamo lighting set is used. In our country, it is much available because of its cheap price. Power extraction device from small scale like is used in bi-cycle. Wells turbine (Fig. 10) is mounted to its shaft. When the wells turbine rotates using the compressed air flowing over it, generator shafts also rotate. Thus, power is extracted.

Fig. 8: Wells turbine.

Fig. 9: Bi-cycle dynamo. (Used as generator: 12 V / 6 W).

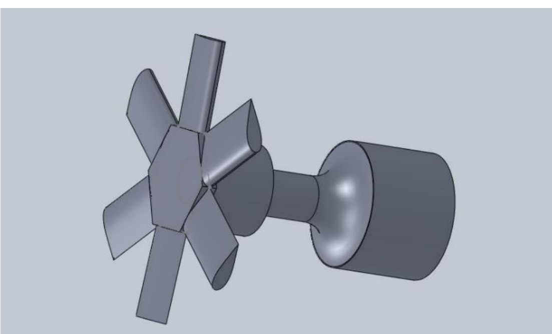

Fig. 10: Wells turbine mounted with generator shaft.

7) Transformer and Wheatstone bridge

A transformer of 1: 12 turn is used to make AC voltage amplification to 12 volt which is connected with the two terminals bi-cycle generator (Fig. 9). Further, a Wheatstone circuit is used as a rectifier to make AC current to DC current (Fig. 11). It will be used to charge the battery (Fig. 12). Here, silicone diodes of 0.7 Volt are used.

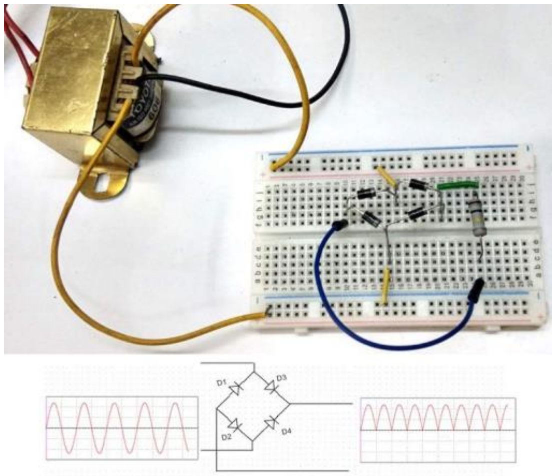

Fig. 11: Transformer and Wheatstone bridge.

8) Battery

A 12v battery of 10 Ah is used to store electrical energy which deliver power when load is not available.

9) LED

A light-emitting diode (LED) is a two-lead semiconductor light source that resembles a basic p-n junction diode, except that an LED also emits light. When an LED's anode lead has a voltage, it is more positive than its' cathode lead for the LED's forward voltage drop at least, current flows. LED was used to check either there is current flow or not as well as power generation. The terminals of LED are connected with the two terminals of battery. (Fig. 12 and 13)

Fig. 12: Battery.

Fig. 13: LED (Source: https://create.arduino.cc/projecthub/rowan07/make-a-simple-led-circuit-ce8308)

2.3. Block diagram

The whole process described above material and method is given below by block diagram at Fig. 14.

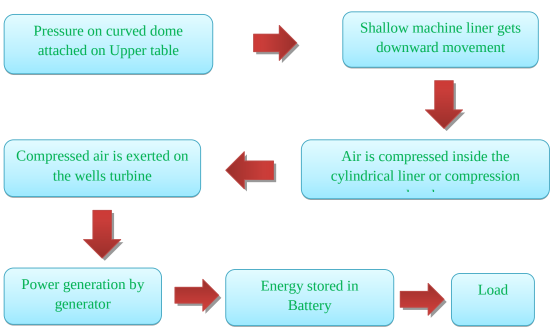

Fig. 14: Block diagram of power generation.

3. Results and discussion

3.1. Theoretical calculation (Approximate)

From Tab. 1 it is seen that Power developed for one day = 1.764 kWh [19]

3.2. Experimental calculation

From Tab. 2 it is seen that the experimental value is 1.716 kWh which is closer to theoretical value and efficiency is very good.

3.3. Average Efficiency

It is calculated from all data from Fig. 15 and 16. Serial 3 in Tab. 2 is different for every power.

Here we calculated for two different cycle. Average efficiency= $\Sigma\ \eta_i /$ number of counts = 83.7%

3.4. Cycle -1 & 2

Time $= \frac{1}{\text{cycle}} = \frac{1}{2.4}$ sec and Time $= \frac{1}{\text{cycle}} = \frac{1}{2.6}$ sec

Experimentally data is collected for two frequencies. Those are 2.4 Hz (60 cycle in 25 seconds) and 2.6 Hz (78 cycles in 30 seconds). Force is exerted manually on the upper base. This force is transferred to piston of compression chamber via connecting rod which compresses the air. This compressed air is flowed on the blade of the wells turbine mounted with generator. Compressed air rotates the generator blade at a speed (RPM range: 1000 ∼ 2100). The rotation of blade produces power for lighting. Figures have been plotted from the experimental data which has shown below:

From all graphs, it is clear that power is not linear as changing of RPM and load . From Fig. 15 and 16, it is seen that both RPM and load are increasing with the increase of power. From Fig. 17 and 18, it is also visible that RPM and load increase more sharply for frequency 2.6.

Tab. 1: Theoretical calculation.

Serial	Formula	Data	Result
1	Work done = Weight (W) × Distance (x) = Mass (m) × gravity (g) × Distance (x) = mgx	m = 75 Kg x = 10 cm	W = 73.5 J
2	Output power per min (P') $= \frac{Work\ done\ (W)}{Time\ (T)}$	W = 73.5 J T = 60 sec	P' = 1.225 W
3	Power developed for one hour (P") = P' × Time (t')	P' = 1.225 W t'= 3600 sec	P" = 73.5 watts-hr
4	Power developed for one day (P) = P" × Time (t)	P" = 73.5 watts-hr t = 24 hr	P = 1.764 kWh

Tab. 2: Experimental calculation.

Serial	Formula	Data	Result
1	Power (P') = Voltage(V) × Current (I)	V = 1.51 V I = 0.793 A	1.19 W
2	Power developed for one hour (P") = P' × Time (t')	P' = 1.19 W t' = 3600 sec	P" = 71.4 watts-hr
3	Power developed for one day (P) = P" × Time (t)	P" = 71.4 watts-hr t = 24 hr	P = 1.716 kWh
4	Maximum Efficiency (η) = Experimental power/Theorical Power	η = 71.4/73.5 × 100%	η = 97.14%

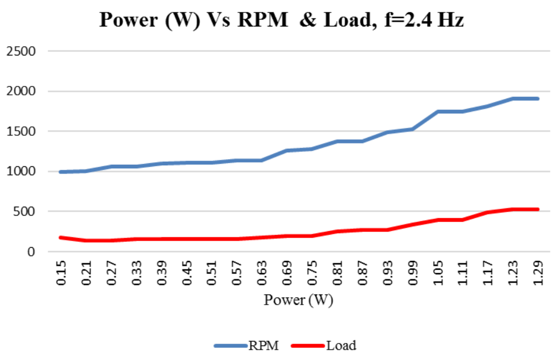

Fig. 15: Power (W) Vs RPM & Load, f = 2.4 Hz.

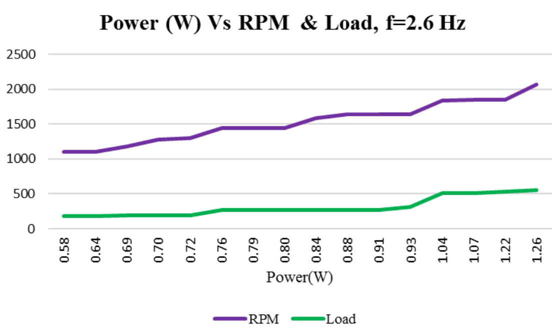

Fig. 16: Power (W) Vs RPM & Load, f = 2.6 Hz.

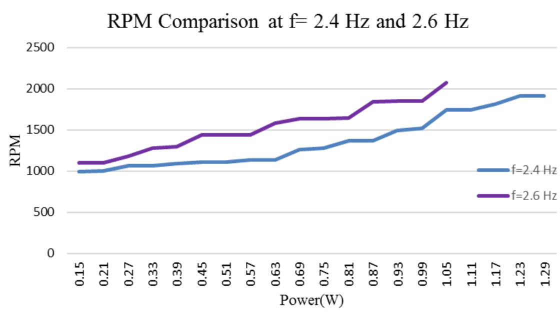

Fig. 17: RPM vs Power Comparison at f = 2.4 Hz and 2.6 Hz.

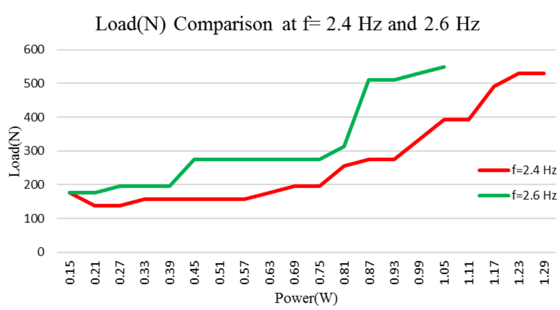

Fig. 18: Power Comparison vs Load at f = 2.4 Hz and 2.6 Hz.

4. Conclusions

In the coming days, demand for electricity will be very high as it is increasing every day, speed breaker power generator will prove a great boom to the world in the Future [15]. This paper is a one-step way to explore the possibilities of energy from alternate green source. The speed breaker model is found to be useful in utilizing potential energy of vehicles (weight) which is lost on speed breakers. In our study, this model has been introduced on the basis of wells turbine. 1.716 kWh power per day has been found for 75 Kg weight which is better than the result of Mr. Amol Sheshrao Fawade [9] and Kiran Kolhe and Amar Pandhare [10] and Mohamad Ramadan et al. [17]. The study has found average current, average voltage and range of RPM are 0.7 A, 1 volt and 1000-2100 respectively. If this model is implemented in large scale, it might be able to extract considerable amount of power from this system. From the proposed concept, it is easy to produce electrical energy for the working of street light, lamppost where cost will be very low comparing other conventional energy and renewable energy as plywood, wooden blades and plastic materials have been used. Investment cost will be low for using available material. This generated power can be amplified and stored by using different electric devices. By adopting this arrangement, we can satisfy the future demands to some extent [14].

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